Dave Beauchamp-Response to Questions for reviewers

General Trends (Sections II and III):

1. Of the population trend indicators described above, which do you think are the most reliable and informative?

Each of the metric described offer somewhat different strengths and types of information, and they should be used as complementary. Trends in gill net CPUE should provide the most reliable, integrated (among spawning populations), and comparable indicator for most species (floating gill net CPUE for westslope cutthroat, sinking gill net CPUE for other species), **IF** sampling occurs during an environmentally-stable period of the year when species are not affected by life stage transitions or migrations (e.g., ideally during summer stratification). Even though CPUE could be lower for species like lake trout, differences in CPUE should more consistently reflect changes in the abundance of a species without the potential ambiguity of environmental forcing. Spring and fall are dynamic periods, when environmental conditions can vary dramatically among years on the same calendar dates. Thus, CPUE during spring and fall monitoring periods can vary because of interannual differences in distribution patterns or activity rather than true differences in abundance. Because of the possibility of environmentally-mediated inter-annual variability, spring gill net CPUE should be used cautiously when evaluating trends (i.e., consider climatic anomalies before concluding that change has occurred), but should still be used as a primary indicator of population status (based on CPUE and size structure for gamefishes except pygmy whitefish and kokanee). Note that bull trout gill net CPUE and adult redd counts agreed reasonably well in years when both types of data were recorded.

As noted by the co-managers, monitoring trends of low-abundance species like bull trout and westslope cutthroat trout become challenging. Under these conditions, finer-scale measures (redd counts, age-specific juvenile densities, age-specific lake migrant trapping) provide more mechanistic/diagnostic data for identifying potential problems or remedies, but might produce more variable and thus ambiguous trend data for the composite population of a species.

Trends in catch and size by anglers will be least reliable indicators of the population, due to the vagaries of behavior and efficacy within among individual anglers through time.

Bull trout trends.

a. Do redd count data exist before 1979? Redd counts increased, then remained high through the most dynamic period of mysid-lake trout-kokanee-lake whitefish response (1980-1990).

b. How do climate data (drought, max-min stream temp, discharge, etc.) track with bull trout redd trends?

2. It has not been easy to demonstrate trends in lake trout abundance. Are there other population trend indicators you think are more useful than the ones we have used?

DB2-Lake trout trends.

1. CPUE in sinking gill nets and associated length frequency distributions should provide the most robust long term trend data. Consider shifting to a summer monitoring period IF

inter-annual environmental anomalies were likely to be significant in the past (for reasons mentioned in question 1 above). If summer surveys are implemented, then several years of spring AND summer surveys would be needed to calibrate any adjustments needed to meld past data with the future.

2. Slower growth should not necessarily be considered as evidence of a stable or increasing lake trout population. Slower growth can be the consequence of:
a. Less per capita food consumption due to reduced prey availability.
b. Less per capita food consumption due to more competition from more lake trout (density dependent growth limitation) or other competitors.
c. Lower energy food source.
d. Increased metabolic cost due to environmental stress (anomalous temperature, oxygen, or contaminant levels) or ecological interactions (higher costs for foraging, migration, etc.).
Declining growth (lower size-at-age) in lake trout in this case appears to be driven primarily by option c, a shift from high quality prey (kokanee energy density > 5000 J/g) during pre-mysid era to lower quality prey (mysids, energy density = 2300-2450 J/g wet Wt, Wicklum unpublished data) thereafter. Whitefishes exhibit relatively high, but seasonally volatile energy densities. Mysids currently dominate the energy budget of lake trout TL ≤ 625 mm. Lake trout larger than 625 mm TL probably have very little scope for faster growth, given the allometric inertia and annual spawning costs experienced by these fish. In other words, size-at-age has largely been set earlier in life, during the ages when mysids dominated the diet.

3. Lake trout mortality from size-at-age and size frequency trends in catch. Four estimators all converge into a range of annual mortality of Z=0.3-0.34 per year. This equates to annual survival rates of S=71-75%.

Factors controlling bull trout abundance (Section III A.)

3. Coal Creek has been an anomaly among spawning tributaries. Which explanation do you think most reasonably explains the differential response of bull trout in Coal and Big creeks; differential response to in-stream habitat conditions, or differential mortality in Flathead Lake, or a combination of the two?

DB3-In-stream habitat conditions are the more likely cause of differential mortality between Coal Creek and other spawning tributaries. However, differential mortality in Flathead Lake could be important if:

a. Coal Creek produces smaller or younger migrants to the lake.
b. Timing of lakeward migration differs from other tributaries such that this creates either higher vulnerability to predators (northern pike downstream or lake trout, bull trout, and northern pikeminnow in the lake) or a temporal mismatch with their primary food supply.

4. While bull trout declined substantially in the past two decades, we think they are now stable. This raises the importance of knowing whether this condition

can persist well into the future? What do you think is the likelihood that lake trout will completely eliminate bull trout in Flathead Lake in the long term?

DB4-There is <u>high likelihood</u> that lake trout will completely eliminate bull trout in Flathead Lake over the long term. This will be the result of the lower overall resilience of bull trout due to a combination of:

a. Dramatic shift in historic high-energy food supply (kokanee, and perhaps reduced supply or spatial accessibility to smaller-bodied native coregonids). This would affect growth rate in the lake and prolong exposure to a larger pool of predators, and could reduce reproductive success.
b. Direct predation by lake trout and perhaps elevated cannibalism by larger bull trout as a consequence of the new trophic regime.
c. Shift in life stage-specific distribution and movement patterns of bull trout in response to increasing lake trout population (due to predation risk, altered prey community, or agonistic interaction).

Growth of lake trout (Section III B.)

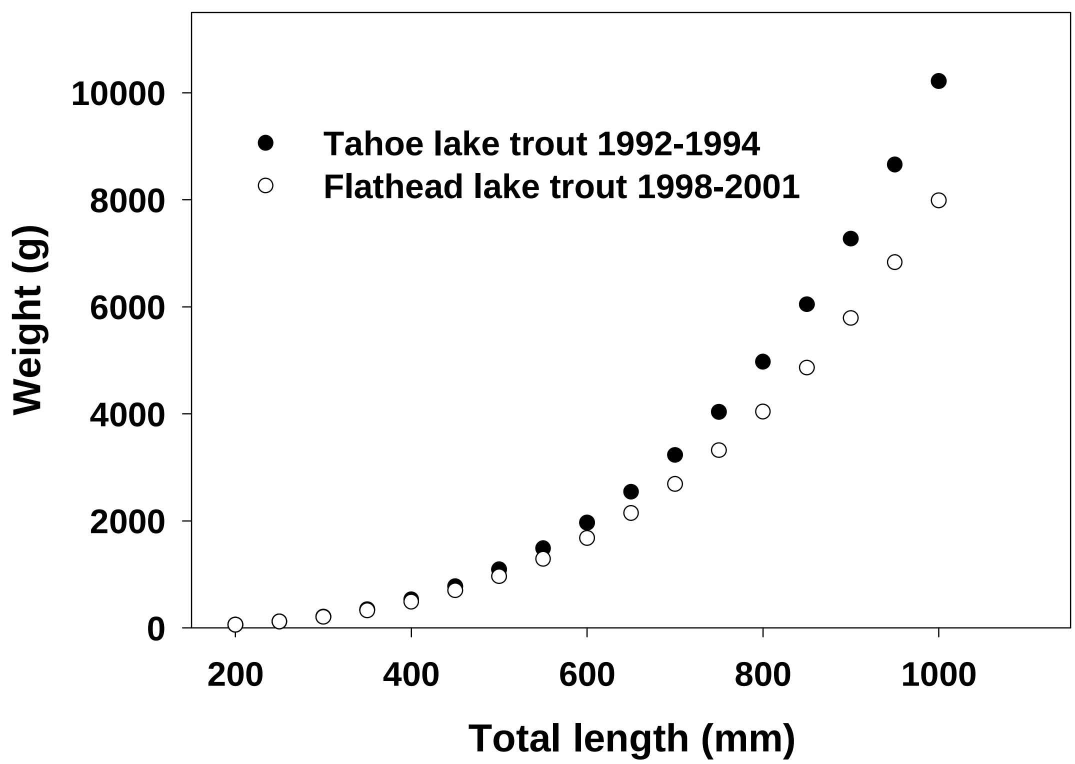
5. We are surprised by the large changes in growth of lake trout and are concerned about accuracy in aging. Have you observed similar changes in growth rate of lake trout over a fifteen year period to what we have seen in Flathead Lake?

DB5-Lake Tahoe lake trout appeared to grow faster as juveniles then slower as adults after the mysid introduction (Pre-mysid data from Hanson & Cordone 1967).

6. We are also surprised by the very low condition factor of these lake trout. Do you know of examples where lake trout (>8 years old) in communities of *Mysis*, yellow perch and coregonids have higher condition factors than the Flathead population?

DB6-Lake trout in Lake Tahoe exhibit higher body condition than in Flathead Lake. In Lake Tahoe, they also feed primarily on mysids (50-75% of diet by weight for lake trout < 625 mm TL), followed by sculpin, native minnows, suckers, crayfish, and lake trout.

Flathead Lake 1998-2001 (r^2 = 0.978; $P < 0.001$; N = 426): Wt(g) = $0.0000055*TL^{3.054}$
Lake Tahoe 1992-1994 (r^2 = 0.957 $P < 0.0001$; N = 751): Wt(g) = $0.0000021*TL^{3.229}$



7. We have been working with length at age rather than measuring annual increments, meaning that growth within the year of capture is important for comparison. When during the year is the lake trout annulus formed?

DB7. When are annuli formed on otoliths?

Presumably annulus formation is completed at some point during late winter; however, since formation times could vary among populations, the timing (which month?) of annulus formation on lake trout otoliths is uncertain. Timing might be detected opportunistically by examining the margins of sectioned otoliths collected during different months. This examination should be confined to younger ages (e.g., ages 4-8), because marginal growth beyond the final annulus should be easier to discriminate for the younger, faster growing life stages. If otoliths were removed routinely during the 1998-

2001 sampling program, reasonable sample sizes should exist for lake trout < 525 mm TL (age approximately ≤ 8 years) from:
Feb 2001 (N=30)
Mar 1999 (11)
Apr 1999 & 2000 (29)
May 1999 mostly but some from 1998 & 2000
Nov 1998 (26) and 2000 (5)
Dec 2000 (10)

8. There should be a lottery prize for this question. Can you provide an explanation for the increase in length at maturity, knowing that growth rate has decreased over the time period?

DB8. Why has length at maturity increased while growth rate declined?
Even though lake trout feed at a relatively high rate, lower growth efficiency, due to a lower-quality prey base dominated by mysids (until TL > 625 mm) instead of fish, could increase size and age at maturity, and perhaps also reduce size-related fecundity.

Since cannibalism appears to be a significant source of size-selective mortality, energy allocation during early years of life could prioritize somatic growth in terms of length at the expense of total body energy stores (Biro et al. 2005), and could presumably delay gonadal investment. By initially prioritizing growth in length by sacrificing energy storage, younger lake trout could reduce their risk of cannibalism quicker (by outgrowing the gape-limitation of their predators), but would be less fit to reproduce.

Uncertainty about harvest of lake trout (Section IV)

9. While managers are striving to reduce lake trout, the fact remains that lake trout provide the bulk of angling opportunity in Flathead Lake. There is a concern by some that we might over-shoot our lake trout exploitation target. If so, what are the likely ramifications to the future lake trout population?

DB9-Angling can likely change the size structure of the lake trout population, but is less likely to significantly reduce the whole population in a sustainable manner. Under current conditions, even if lake trout became over-exploited, I would expect the population to rebound rapidly (e.g., within 5 years) in response to corrective harvest regulations. The ecological conditions that enabled the rapid population increase during the 1980s still persist.

10. There is also concern that a reduction in lake trout will cause an increase in *Mysis*. If so what secondary ecosystem effects do you anticipate?

DB10-Simulations by Beauchamp et al. 2006 suggest that lake trout reductions will result in an increase in lake whitefish, yellow perch, and a small net increase in mysid production: if removed in proportion to their abundance by size, for every 1,000 lake trout ≥200 mm TL harvested, mysid densities would increase by 0.13/m^2. To put this in perspective, mysid densities have averaged a consistent 44/m^2 during mid-summer in recent years (Ellis et al. 2001, personal communication), so removing 100,000 lake trout in proportion to their existing size structure would increase mysids by an additional 13/m^2, representing a 30% increase in mysid density. These simplistic computations assume that all existing processes, as we understand them, would respond linearly. In reality, compensatory feedbacks or threshold effects would likely modify this scenario considerably. Although more analysis would be required to support the following speculation, planktivorous fishes are likely regulated more by lake trout predation than food limitation; therefore, planktivorous fish populations could increase if lake trout were reduced, despite the expected increase in competition from mysids. Based on Figure 6 of the report (Hansen et al. 2006, Technical Fisheries Data Section), a general reduction in lake trout abundance would reduce predation mortality on native fishes, lake whitefish, and yellow perch. Targeting reductions on lake trout > 625 mm TL should significantly reduce predation mortality on bull trout and westslope cutthroat trout while maintaining reasonably high predation rates on lake trout and yellow perch, but would probably allow lake whitefish to increase.

11. Based on the information in the summary, do you think we may be on the right side of the peak in the stock/recruitment curve such that a reduction in the lake trout population could increase rather than decrease recruitment?

DB11-Although it might be possible that a proportional reduction in the lake trout population could increase recruitment, this possibility would be much less likely if reductions targeted lake trout >625 mm TL. Differential removal of the larger lake trout (especially 625 mm < TL < 750 mm) would both reduce the abundance of the most effective predators on native bull trout and westslope cutthroat trout and reduce the number of highly fecund females.